

NSF funds Center for Innovative Brain Machine Interfaces



The McKnight Brain Institute is one of the partners involved in the proposed Center for Innovative Brain Machine Interfaces

The National Science Foundation's Partnership for Innova-

tion program has announced that it will fund CNEL's proposal for a Center for Innovative Brain-Machine Interfaces (CIBMI). The CNEL proposal was selected as the only proposal to this program to be submitted by UF, and this award attests to the novelty and quality of the CNEL proposal.

The CIBMI will create a fast track for research, development, testing, and commercialization of the most advanced "beyond state-of-the-

art" technologies for brain-machine interfaces, potentially enabling brain-injured individuals a chance to resume normal function.

At the same time, the CIBMI will add a new dimension to graduate engineering education, giving graduates the business savvy to turn their scientific discoveries into profitable companies, and increasing high-tech, high-wage jobs for Floridians.

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CNEL Seminars

- CNEL SEMINARS ARE HELD ON TUESDAY AFTERNOONS AT 2:00 IN NEB 409.
- SEMINARS FEATURE PRESENTATIONS FROM CNEL STUDENTS, FACULTY MEMBERS, AND VISITORS.
- FOR MORE INFORMATION, SEE OUR WEBSITE, WWW.CNEL.UFL.EDU

Congratulations to our Graduates

Congratulations are in order for Dongho Han, Yuan Li, Harsha Sathyendra, and Yi Zheng, who successfully defended their dissertations at the end of the Fall 2006 semester.

The title of Dr. Han's work was "A new class of sparse channel estimation methods based on support vector machines," while Dr. Li's is "An integrated multichannel neural recording system with spike outputs." Dr. Sathyendra dissertation was "Robust speaker-independent bandwidth extension for mobile and landline communications." Dr. Zheng defended "Classification of Neuronal Firing Patterns using Multi-Fractal Analysis."

Ph.D. proposals were presented this semester by Seung Ju Han (Optimization Algo-



Some of CNEL's finest: **BOTTOM L-R: Antonio Paiva, Puskal Pokharel, Mustafa Can Ozturk, Jianwu Xu. TOP: L-R Mariana Almeida, Yiwen Wang, Justin Sancez, Jack DiGiovanna, Jose Principe, Kyu-Hwa Jeong, Sudhir Rao, Aysegul Gunduz**

ritms for Adaptive Information Processing: Family of Minimum Renyi's Error Entropy Algorithm), Kyu-Hwa Jeong (The Correntropy MACE filter for Image Recognition), Puskal Pokharel (Basic Time Series

Analysis with Information Theoretic Learning and Kernel Methods, and Yiwen Wang (A Monte Carlo Sequential Estimation of Point Process Optimum Filtering for Brain Machine Interfaces).

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The Sid Martin Biotechnology Development Incubator is a leading resource for local and regional biotech startup companies.

INFORMATION
THEORETIC LEARNING
IS BASED ON
LEARNING FROM
EXAMPLES IN
BIOLOGICAL AND
ARTIFICIAL SYSTEMS,
AND APPLYING THIS
KNOWLEDGE
TOWARD
DEVELOPING
LEARNING MACHINES.



Dr. Jose Principe, Distinguished Professor and Director of CNEL, has created an online course on Information Theoretic Learning.

CIBMI, continued from Page 1

The CIBMI will combine elite scientists, successful entrepreneurs, and engineering graduate students into “virtual companies” to develop, test, and transfer new technologies into actual business ventures. Local and regional biotechnology entrepreneurs have agreed to participate as consultants, and would act as virtual CEOs. UF scientists and engineers will participate as Chief Technical Officers to guide the technological discovery and development.

This unique approach will accelerate the development of new biomedical technologies, and participating graduate

students will learn the business side of biomedical engineering.

Our UF partners in this venture are: College of Engineering Office of Industrial Programs, Department of Biomedical Engineering; Sid Martin Biotechnology Development Incubator; McKnight Brain Institute; College of Medicine Rehabilitation Program; Veterans Administration Hospital; Center for Entrepreneurship and Innovation; Warrington College of Business; and the Office of Technology Licensing.

Florida International University in Miami is also part of the academic team.

Local and regional partners include: City of Gainesville Department of Economic Development; Technology Enterprise Center of Gainesville/Alachua County; Inflexion Partners; Tucker Davis Technologies; Motorola; Neurotronics; Convergent Engineering; Advanced Neuromodulation Systems (Texas).

Through the proven excellence of the UF biomedical engineering community, and the strength and commitment of our partners, CIBMI will advance the progression of cutting-edge technologies from fundamental research and education through technology development and transfer.

Principe creates IEEE Information Theoretic Learning Online Course

Information Theoretic Learning (ITL) is an approach to capturing information about a real-world event in the parameters of a learning machine. The theoretical framework and associated algorithms of ITL are among the most advanced ideas being researched and refined currently in CNEL.

To bring this research to the brightest minds in industry, Jose Principe, CNEL Director, teamed with IEEE’s Educational Activities Board to create an online course module, which will soon be available as part of IEEE’s Expert Now series.

Expert Now courses are developed by leading scientists and engineers in their respective fields, are peer

reviewed, and are designed to provide industry professionals with a self-paced, rapid method to keep abreast of the latest developments in engineering. The course modules are available online at http://www.ieee.org/web/education/Expert_Now_IEEE/index.html.

In CNEL, we envision a time where brain and machine can interface through conscious thought, enabling normal function in cases of brain injury or disease. Key to this goal, and integral to ITL, is learning from examples in both biological and artificial systems, where the huge amount of data which characterizes an actual event is extracted and, based on Information Theory, is translated into manageable information.

In this case, “information” is a precise mathematical quantity to which a set of algorithms can be applied, and the results used to “train” the machine. In mathematical terms, ITL synergistically integrates the general framework of information theory into the design of new cost functions for adaptive systems.

Sharing this cutting-edge knowledge with engineering professionals through IEEE should encourage further ITL research and collaboration, potentially bringing us closer to our goal of a seamless brain-machine interface.

For more information on ITL, please see our website, www.cnel.ufl.edu.

Visiting Scholars add vigor to CNEL research

The vibrant CNEL research environment continually attracts visiting scholars who bring new ideas and perspectives, further invigorating the lab. During the Fall 2006 Semester, we were pleased to host Mariana Almeida (Portugal), Allan Martins (Brazil), Johan Nyqvist (Sweden), and Rodrigo Sacchi (Brazil).

Aside from craving a good cup of Portuguese coffee and hankering for homemade Brazilian black beans, our visitors collectively expressed that their experiences at CNEL and at UF far exceeded their expectations. They enjoyed experiencing UF's National Championship in basketball and SEC championship in football, agreeing that only the World Cup is more significant. At the same time, they found Gator fans relatively tame as compared to European and Brazilian soccer enthusiasts. Most importantly, though, they found the city and university welcoming, and the research environment challenging and rewarding.



Johan Nyqvist is working on his Master's degree through a biomedical engineering program in Sweden.



Mariana Almeida, a Fall Semester CNEL visitor, is working on her Ph.D. at Instituto Superior Tecnico in Portugal

"We are working on things that matter," said Allan Martins, a post doc from the Federal University of Rio Grande do Norte, who is the veteran of the group. He arrived in May, 2006, for a one-year appointment to investigate new metrics that use Information Theory, and applying those metrics to Clustering. Dr. Martins cites the quality and size of the research group, and the way in which Dr. Principe balances individual and group research, as contributing most to his research experience. "He is always pushing – making you think...he is the maestro of the lab," said Dr. Martins.

Rodrigo Sacchi arrived in August, 2006. A Ph.D. student at the University of São Paulo, he conducted research on neural networks and fuzzy systems for time series prediction, and the identification and control of dynamic systems. He is now at UCLA, where he is studying reservoir management and operation. Upon returning to Brazil, Mr. Sacchi will apply this combined knowledge to hydropower system operation.

Mariana Almeida is a Ph.D. student at Instituto Superior Técnico in Lisbon. She arrived in September, 2006, to combine her background in nonlinear independent component analysis with CNEL research in Information Theoretic Learning. Ms. Almeida thrived in the CNEL group, and said that her research was significantly enhanced.

Johan Nyqvist had a slightly different goal than his counterparts. He is working on his Master's degree through a cooperative biomedical engineering program between Sweden's Royal Institute of Technology (KTH) and the Karolinska Institutet in Stockholm. The program is run in Sweden by Professor Rune "Tex" Lindgren, who spent time at UF and has a network of UF faculty contacts. Professor Lindgren sends 6-10 short-term scholars here every year, and they share an apartment. According to Mr. Nyqvist, this was beneficial in that the students were not as homesick as those who came individually, but it also slowed the process of experiencing American culture. While at CNEL, Mr. Nyqvist worked independently to produce a research paper comparing the work of several former CNEL researchers, and will present that work upon returning to Sweden in January. Surprising to him was the absence of the strict hierarchical structure between students and faculty to which he had become accustomed. "You have a better relationship with the professors here," he said. "From that whole perspective, it is better here."



Allan Martins is a post-doctoral researcher visiting CNEL from Universidade do Rio Grande Do Norte in Brazil.

"HE IS THE MAESTRO OF THE LAB," SAYS DR. ALLAN MARTINS OF CNEL DIRECTOR JOSE PRINCIPE.



Rodrigo Sacchi is a visiting scholar from the University of Sao Paulo.

Hybrid Lab wins E-Fair Competition...Again



QING YANG (ABOVE) MODELS THE HEADPHONES USED IN THE HYBRID LAB'S AWARD-WINNING EXHIBIT.

MAYA HARRIS (BELOW) LISTENS TO WHAT SHE MIGHT SOUND LIKE WHEN SHE GETS OLDER.



Hybrid Lab and Audiology volunteers celebrate their second win in two years at UF's Engineering Fair.

If Urban Meyer was inspired by Billy Donovan's Gators, then Coach Donovan need only look to CNEL's Hybrid Lab to motivate his team for successive championships. For the second year running, the Hybrid Lab won the annual Engineering Fair's exhibit contest, bringing home trophies for Audience Involvement and Overall Outstanding Exhibit. The Engineering Fair, held every February, provides regional middle- and high-school students the opportunity to explore the many varied fields of engineering. Hybrid Lab students worked tirelessly

to develop four interactive displays:

"Do You Hear What I Hear" examined how this generation is surrounded by louder sounds and noises than ever before, and demonstrates how our hearing is affected.

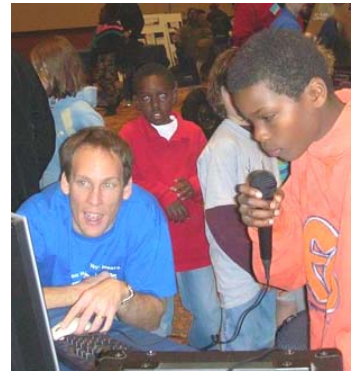
"Music to My Ears" applied current CNEL research to demonstrate how music and cellular phones would sound with different levels of hearing loss.

"Change Your Voice, Hear the Future," allowed participants to examine how the pitch and tone of their voices changes with age and other influences,

like smoking.

"Play It Safe," focused on the use of MP3 players, as participants were able to measure the volume of their music to find out if their ears are safe.

Photos and further details of this outstanding exhibit are available at: <http://www.cnel.ufl.edu/hybrid/efair2007.html>



Jeremy Anderson shows a participant how his voice can be modulated.

Journal Papers

Published:

Ozturk, M., Xu, D., Principe, J. "Analysis and Design of Echo State Networks." *Neural Computation*. Vol. 19, No. 1. pp.111-138.

To Appear:

Li, R., W. Liu, J. Principe. "A Unifying Criterion for Instantaneous Blind Source Separation Based on Correntropy." *Signal Processing*.

Ozturk, M., Principe, J. "An Associative Memory Readout for ESN and LSM for Dynamical Pattern Recognition." *Neural Networks, Special Issue on Echo State Machines*.

M.D. Skowronski and J.G. Harris. Automatic speech recognition using a predictive echo state network classifier." *Neural Networks Special Issue on Echo State Networks and Liquid State Machines*.

M.D. Skowronski and J.G. Harris. Noise-robust automatic speech recognition using a minimum mean-squared error prediction model." *IEEE Transactions on Audio, Speech and Language Processing*

Submitted:

Rao, S. and J.C. Principe. "Mean Shift: An Information Theoretic Perspective." *IEEE Trans. Pattern Analysis and Machine Intelligence (PAMI)*.

Park, I., Paiva, A.R.C., DeMarse, T.B., and J.C. Principe. "An Efficient Algorithm for Continuous-time Cross Correlation of Spike Trains." *J. Neuroscience Methods*.

Jeong, K-H., S. Han, J.C. Principe. "The Correntropy MACE Filter." *IEEE Trans. Pattern Analysis and Machine Intelligence*.

Han, S., S. Rao, D. Erdogmus, K.H. Jeong, and J. C. Principe. "A Minimum Error Entropy Criterion with Self-Adjusting Step-Size." *EURASIP Journal of Signal Processing*.

Where are they now: Deniz Erdogmus

Deniz Erdogmus remembers fondly the occasional appointment of a CNEL trash manager. As time passed in the lab, “leaving students to their natural dynamics caused entropy to increase – this manifested itself as clutter and paper piles in the lab. When this entropy exceeded Principe’s internal threshold, it was time to appoint a trash manager.” The trash manager’s job was to lie patiently in wait for a week while the disorder increased, and then collect everything in sight and put it in the trash. Afterward, CNEL veterans enjoyed watching their cohorts, “who did not take the warnings seriously, looking for their important equations, notes or papers in the trash bins.”

A CNEL Research Assistant and Post Doc from 1999-2004, Dr. Deniz Erdogmus is now an Assistant Professor in the Department of Biomedical Engineering and the Department of Computer Science and Electrical Engineering at Oregon Health and Science University in Portland, and enjoys his work. His CNEL background in information theory has evolved into an interest in differential geometry and multilinear (tensor) algebra, and their applications to statistical signal processing and machine learning, brain machine interface design, and unobtrusive monitoring of the elderly for cognitive health diagnosis. He supervises four Ph.D. students in these areas. Especially valuable to Dr.

Erdogmus while at CNEL was the “large group and collaborative environment, excellent colleagues – especially Yadu [Rao] and Kenny [Hild] – with whom I spent a lot of time discussing ideas at the white board.” He also complimented Dr. Principe’s “motivating and liberal approach to advising...providing many options and letting me figure out details.” Dr. Erdogmus admits, though, that not everyone has what it takes to survive a tour in CNEL.

“Do NOT be a student, be an independent, self-confident researcher!”

And watch out for the trash manager.

Dr. Erdogmus home page is here:<http://www.cse.ogi.edu/~deniz/>

DENIZ ERDOGMUS’ RULES FOR SURVIVAL AS A PRINCIPE ADVISEE:

1. Pay attention to what Dr. Principe thinks.
2. Filter out nonessential elements using your best judgment based on your research goal and how these ideas connect.
3. Using rigorous math and experimentation, do what you think is right and explain clearly how this connects back to the original ideas discussed and the overall research goal.
4. For a few years at least, keep in the back of your mind your original ideas that you dismissed in step 2. You will be surprised to see that what you thought was irrelevant at the time and dismissed was in fact a good idea for future work!

Conference Papers

Submitted to 20th International Joint Conference on Neural Networks (IJCNN) 2007

Dedual, N., M.C. Ozturk, J.C. Sanchez, J. C. Principe. “An Associative Memory Readout in ESN for Neural Action Potential Detection.”

Darmanjian, S., A. Paiva, J. Principe, J. Sanchez. “Hierarchical Decomposition of Neural Data using Boosted Mixtures of Independently Coupled Hidden Markov Chains.”

Han, S., S. Rao, D. Erdogmus, J. Principe. “A Novel Switching between Adaptive Information Algorithms.”

Liu, W., P. Pokharel, J. Principe. “Kernel LMS as Solving a Lower Triangular Linear System.”

Paiva, A.R.C., S. Rao, I. Park, J. Principe. “Spectral Clustering of Synchronous Spike Trains

Park, I., A.R.C. Paiva, J.C. Principe, J.G. Harris. “A Closed Form Solution for Multiple-Input Spike Based Adaptive Filters.”

Rao, S., S. Han, J. Principe. “Information Theoretic Vector Quantization with Fixed Point Updates.”

Rao, S., A.R.C. Paiva, J.C. Principe. “A Novel Weighted LBG Algorithm for Neural Spike Compression.”

Submitted to 3rd International IEEE EMBS Conference on Neural Engineering (NER) 2007

Cheney, D., A. Goh, J. Xu, K. Gugel, J.G. Harris, J.C. Sanchez, J.C. Principe. “Wireless, In Vivo Neural Recording using a Custom Integrated Bioamplifier and the Pico System.”

DiGiovanna, J., B. Mahmoudi, J. Mitzelfelt, J.C. Sanchez, J.C. Principe. “Brain-Machine Interface Control via Reinforcement Learning.”

Gunduz, A., M.C. Ozturk, J.C. Sanchez, J.C. Principe. “Echo State Networks for Motor Control of Human ECoG Neuroprosthetics.”

Li, R., J.C. Principe, M. Bradley, V. Ferrari. “Single-trial ERP estimation based on spatio-temporal filtering.”

Wang, Y., J.C. Sanchez, J.C. Principe. “Information Theoretical Estimators of Tuning Depth and Time Delay for Motor Cortex Neurons.”

Rogers, C., J.C. Harris, J.C. Principe, J. Sanchez. “A Pulse-based Feature Extractor for Spike Sorting Neural Signals.”

Submitted to International Conference on Machine Learning and Signal Processing (MLSP) 2007

Liu, W., P. Pokharel, J. Principe, “Recursively Adapted Radial Basis Function Networks and its Relationship to Resource Allocating Networks and Online Kernel Learning”

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The 2007 ICAASP conference will be held in Honolulu, Hawaii.

The Computational NeuroEngineering Laboratory explores the principles that guide our ability to comprehend brain function, treat brain disorders, and ultimately to interface directly with the brain. Our researchers combine principles from machine learning, signal processing theory, and computational neuroscience to advance the science of engineering systems. On the horizon is a technological revolution, where machines can be controlled by the brain. We envision a time when brain and machine can interface through conscious thought, enabling normal function in cases of brain injury or disease.

CNEL's Hybrid Computation Group combines elements of analog/digital and biological/artificial in an effort to develop biologically inspired algorithms for sensory and neural processing.

Visit us on the web:
www.cnel.ufl.edu

Upcoming Events

Conference	Location & Date	Early Registration
International Conference of Engineering in Medicine and Biology Society (EMBS 2007) www.embc07.ulster.ac.uk	Lyon, France Aug. 23-26, 2007	Jul. 15, 2007
International Joint Conference on Neural Networks (IJCNN 2007) www.ijcnn2007.org/	Orlando, Florida Aug. 12-17, 2007	Jun. 12, 2007
International Workshop on Machine Learning for Signal Processing (MLSP 2007) mlsp2007.teithe.gr/	August 27-29, 2007 Thessaloniki, Greece	Jul. 2, 2007
11 th International Conference on Cognitive and Neural Systems (ICCNS 2007) cns-web.bu.edu/cns-meeting.conference.html	May 16-19, 2007 Boston, Massachusetts	Apr. 15, 2007

Conference Papers, continued

To appear in Proc. IEEE International Conference on Circuits and Systems (ISCAS) 2007

- Uysal, H. Sathyendra, and J.G. Harris. Spike-based feature extraction for noise robust speech recognition using phase synchrony coding.
- X. Gong and J.G. Harris. A precompensation algorithm for pwm-based digital audio amplifiers for portable applications
- A. Camacho and J.G. Harris. A pitch estimation algorithm based on the smooth harmonic average peak-to-valley envelope.
- M.D. Skowronski and J.G. Harris. Noise-robust automatic speech recognition using a discriminative echo state network.
- R. Bashirullah, J.G. Harris, J. Sanchez, T. Nishida, and J. C. Principe. Florida wireless implantable recording electrodes (FWIRE) for brain machine interfaces.

To appear in Proc. IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) 2007

- Uysal, H. Sathyendra, and J.G. Harris. A duplex theory of spike coding in the early stages of the auditory system.
- Jeong, K-H., S. Han, J.C. Principe. "The Fast Correntropy MACE Filter."